THE LATER CENOZOIC HISTORY OF THE WIND RIVER MOUNTAINS, WYOMING

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INTRODUCTION

The Wind River Mountains of West Central Wyoming run from Union Pass on the north, for over one hundred miles southeast to the Sweetwater River near Atlantic City. The range rises from the plains level of 5,000 to 6,000 feet on the east, to a crest line which in a number of places stands over 13,000 feet above the sea. Wind River Peak is 13,500, and Gannett Peak, the highest summit in the range, 13,785 feet above the sea.

The continental divide follows the crest of the range. On the east the drainage is by the Wind River and Platte and its tributaries to the Missouri and the Atlantic. Along the west side, except at the south end where the drainage is by the Sweetwater to the North Platte and the Atlantic, the streams are tributary to the Green River, thence following the Colorado to the Pacific.

Geologically the structure of the range is similar to that of the Big Horns and the Black Hills, and consists of a central axis of crystalline rocks, circled by belts of upturned Paleozoic and Mesozoic rocks, beyond which lie the nearly level Tertiaries. Along most of the east side of the range the conditions in the Black Hills are exactly reproduced, but along much of the south and west sides the Tertiaries overlap the Paleozoics and rest directly against the crystallines. Where all the formations are present each plays a distinctive part in the topography. The crystalline rocks form the central part of the range. The Paleozoics form the main foothills and slopes up to 9,000 or 10,000 feet, while the Mesozoics and Cenozoics underlie the plains. The lowest Mesozoic and highest Paleozoic, the Chugwater Red Beds, which are mainly sandstone, often make prominent ridges, rising 1,000 to 1,500 feet above the neighboring valleys, facing the range, and sometimes separated from it by a conspicuous red valley, worked out on the softer

shales which comprise the lower part of the Chugwater. In the Cretaceous certain sandstones make low ridges, but not at all comparable with those made by the Chugwater. When the Paleozoics are concealed by the Tertiary overlap the topography is simpler, and the rise from plains to mountains more abrupt.

The observations which are recorded in this paper were made in August and September, 1911, on a trip along the base of the range from the headwaters of the Sweetwater River on the west to Bull Lake Creek on the north, with side trips into the range and out onto the plains. The time which could be given to the work was far from sufficient to determine the history of the range fully, and many questions which came up had to be left unanswered. It is thought, however, that the general history of the range, as read in its topography and that of the surrounding plains, has been made out, and that the results are worth making public. We are glad to be able to express our appreciation of the courtesy of Mr. N. H. Brown of Lander, whose maps of Fremont County and of the vicinity of Lander were used in our work. The Fremont quadrangle is the only topographic sheet published by the U.S. Geological Survey which covers any part of the Wind River Mountains. As our field work was to the south of that area, and we were without topographic maps (except those of the Hayden Survey, which were too generalized for our uses), we were obliged to get altitudes by the use of aneroids, and with less opportunity than we would have wished to check such observations by bench marks.

SEDIMENTARY HISTORY: CAMBRIAN TO EARLY TERTIARY

Before the end of Cambrian time a wide transgression of the sea brought conditions of marine sedimentation over the area of the present Wind River Mountains, and from then on to the close of the Mesozoic there was almost continuous sedimentation. If at times deposit was interrupted, as seems probable from the failure to find Silurian and Devonian beds in the series, this did not interfere with the production of an essentially parallel series of sedimentary rocks. The youngest rocks found in the Lander region are the Mancos shale[1] (Colorado), over 6,000 feet, and the Mesa

[1] Woodruff, *Bulletin U.S. Geol. Survey, No. 452*, p. 10.

Verde (Montana), 2,000 feet. At the close of the Cretaceous came the uplift by which the present anticlinal structure of the range was produced. Parallel to the main uplift, and about six to eight miles east from the base of the range, is an anticlinal uplift which brings the Triassic, Jurassic, and Dakota Cretaceous out from under the Mancos shale, producing an interrupted line of hills (especially south of Lander), and forming a longitudinal valley southeast from Lander. This valley is now drained by a number of transverse streams, but this has apparently not always been the case.

Extensive erosion followed the uplift of the region, even before the time of its earliest Tertiary rocks, for we find the Wind River Tertiaries lying on the upturned and eroded edges of the Mesozoic rocks. In early Eocene times, this erosion was replaced, about the base of the mountains, by deposition. The best section of the Tertiary rocks[1] shows along the north face of the Beaver Divide, where the early Eocene (Wind River beds) are overlaid by the Bridger(?) and Uinta, and above an unconformity, by the Oligocene. These Tertiary rocks, largely shales and sandstones, are alluvial deposits laid down by streams from the higher central mountain area. The occurrence in the Beaver Divide Oligocene of a 100-foot gravel layer with bowlders of granite and other crystalline rocks up to a foot in diameter shows not only that there was considerable relief in the mountain region, but that any cover of sedimentaries had been cut through into the crystallines. How long after this the Oligocene deposit continued in the Wind River basin is not known, for the present top of the Oligocene cannot be shown to be the summit of the Tertiary series. Subsequent to Oligocene time came the erosion which ended in the production of the summit peneplain described below. From this point on, the history of the Wind River Mountains is to be read from the land forms and not from the sedimentary rocks.

THE SUMMIT PENEPLAIN

An accordance of summit levels in the central and northern part of the range is believed to be an inheritance from a peneplain which formerly extended throughout the range, and which in its highest

[1] Sinclair and Granger, *Eocene and Oligocene of the Wind River and Big Horn Basins*, Bull. Am. Mus. Nat. Hist., Vol. XXX, Fig. 2 A.

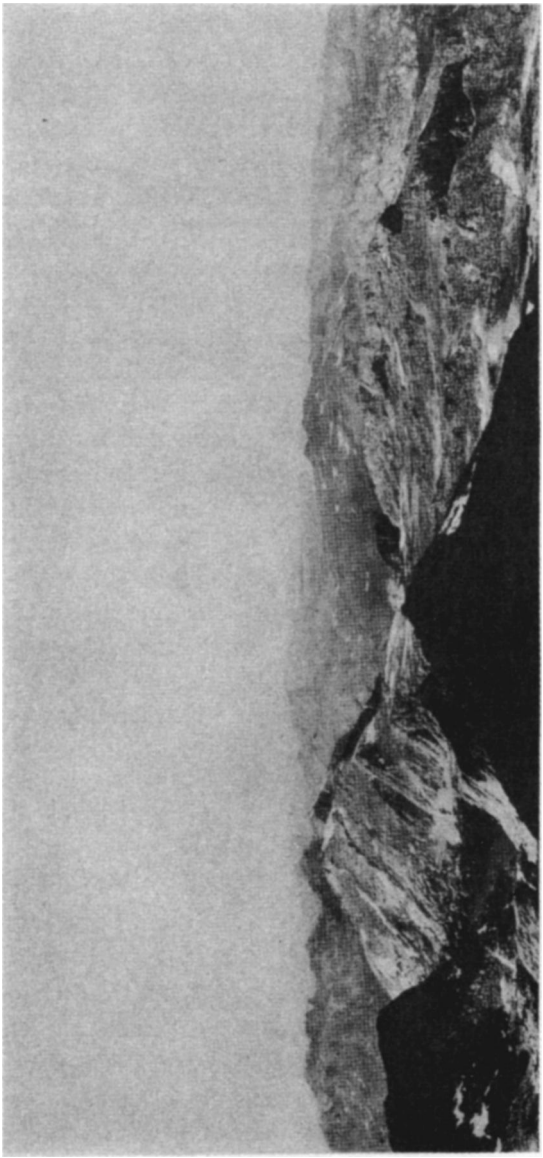

FIG. 1.—View north from Wind River Peak, showing sky line in central part of the range

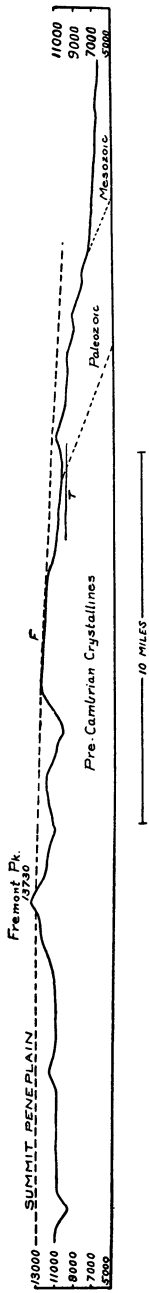

FIG. 2.—Profile across the Wind River Mountains through Fremont Peak. F, flat. T, valley terrace level

remnants now stands about 12,500 feet above sea-level. Looking north from Wind River Peak (Fig. 1) we see the sky line to be composed of rounded summits dropping to the east in an even line, but with occasional points rising sharply above this line. Further north, north and east of Fremont Peak and showing on the Fremont Peak quadrangle, extensive flat or gently rounded areas occur at heights of over 12,000 feet. Such are, the flat east of Indian Pass (Fig. 2, F), Horse Ridge, Goat Flat, the flat along the divide at the north end of the range, and several smaller flats west of the crest. The first two are not strictly level, but rolling, grassed, and rounded upland areas, their higher points rising somewhat above the general flat level.

The whole range was not reduced to the peneplain level. Fremont Peak and the higher points north along the range seem to rise distinctly above the general summit level, and the rate of rise of the ridges or flats which have been named would not carry them to the summit by several hundred feet. We may picture the condition at the close of this epoch as a plain rising along what is now the crest of the range to low rounded hills a few hundred feet in height.

This peneplain is not recognized in the southern part of the range, probably because destroyed by later erosion. From the middle of the range north it is increasingly represented, especially east of the crest. It is preserved only on the crystalline rocks, though the first high escarpment of Paleozoic rocks, the Bighorn limestone, seems to come nearly if not quite to this level. The projection of the plain farther from the crest carries it well above the other Paleozoic scarps. Why it has been more completely destroyed to the south and on the west of the crest, we cannot say.

The remnants of the plain fall into a low arch (Fig. 2), which slopes east from over 12,000 feet along the crest to above 10,000 feet in its last remnants on the edge of the crystallines and the bordering Bighorn limestone, and drops to the northwest along the axis of the range.

The date of the summit peneplain cannot be fixed, from the area studied, more closely than that it is later than the main folding of the range; for it does not extend beyond the Paleozoic rim to any point where later deposits rest upon it. Blackwelder[1] has described a peneplain in the Laramie region of southeastern Wyoming, which makes the summit of the Laramie Mountains at 9,000 feet and cuts the Medicine Bow range at 10,000, with the summits of the latter rising above it as monadnocks. This peneplain is considered to be of post-Eocene age. Rich[2] has described a peneplain in southwestern Wyoming, which had been developed probably by the end of Miocene, while Baker, in a paper read before the Cordilleran section of the Geological Society in 1911, describes the occurrence of a peneplain throughout southwestern Wyoming in the end of the Miocene. Umpleby[3] describes an old erosion surface in West Central Idaho which may prove to be a peneplain and which he considers to be of Eocene age. It is perhaps as much as the facts known at present warrant, to state that the Wind River Mountains had been reduced to a peneplain, except for a few low residuals along the present divide, by mid-Tertiary time.

THE PLAINS AT THE SOUTH END OF THE RANGE

Plain No. 4.—The oldest plain below the summit peneplain is best represented north of Atlantic City, in the summit accordance of a hilly area above which the southern end of the range rises abruptly (Figs. 3, 4, and 5). These summits stand at 8,500 feet farthest from the range, but rise to probably 9,000 feet at its base; and the original plain has been maturely dissected. East of Atlantic City, peaks of Paleozoic limestone rise to the level of this plain at 8,500 feet; and still further east the summit of Sheep

[1] *Journal of Geology*, XVII, 429.

[2] *Ibid.*, XVIII, 601.

[3] *Ibid.*, XX, 139.

Mountain reaches it at about 7,500 feet. The summit of Oregon Buttes, fifteen miles south of Atlantic City may be a remnant of the same plain. They are capped with Tertiary deposits.

This plain was not correlated with any plain-remnants along the range to the north, nor with any valley levels within the range. At the time of its formation, all of the region was reduced to a

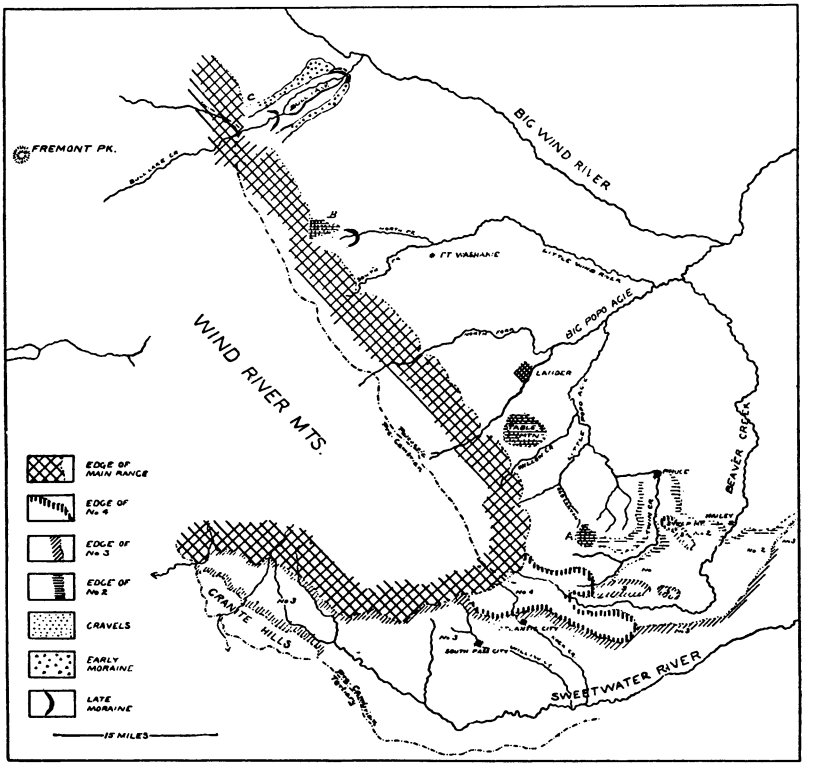

FIG. 3.—Map of the south end of the Wind River mountains, based on a map of Fremont County by N. H. Brown.

peneplain, except the Wind River Range, which rose, at the south, 4,000 feet above the plain level. The date of this plain is post-Oligocene, since it cuts rocks of this date along the Beaver Divide.

Plain No. 3. The Beaver Divide Plain.—Below No. 4 another plain (Figs. 3, 4, and 6) is widely developed about the south end of the Wind River Mountains, and to the east along the divide

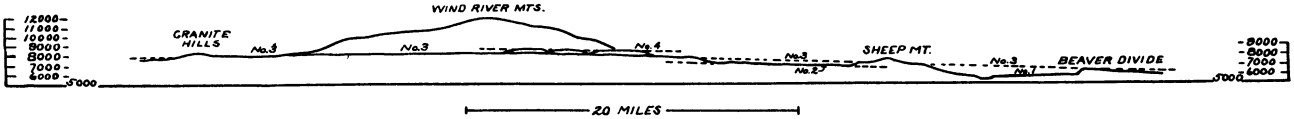

FIG. 4.—Profile of south end of Wind River Mountains

FIG. 5.—Plain No. 4 with the south end of the Wind River Mountains in the distance

between Beaver Creek, and the Sweetwater River. This is plain No. 3, or the Beaver Divide plain.

This plain is best shown west of Atlantic City and South Pass City, where it forms an even plain on the crystalline schists, above which monadnocks (Fig. 6), usually of granite, rise abruptly from a few score to one or two hundred feet. The plain, much cut away, continues west between the Granite Hills and the main range about the headwaters of the Sweetwater, where it cuts both the crystallines

FIG. 6.—View of plain No. 3 and monadnocks, west of South Pass City

and gravels which had earlier been deposited on an irregularly eroded granite surface. This same plain extends east from the south end of the range for over thirty miles along the divide between the Sweetwater River and Beaver Creek cutting in this area practically all the post-crystalline rocks of the region—the inclined Paleozoics and Mesozoics, and the horizontal and consolidated Tertiaries. In a few places residuals of each of these rocks rise above No. 3.

North from Atlantic City, where Nos. 3 and 4 meet, they differ

in level by some 400 feet. The cycle which produced No. 3 passed well beyond maturity, for the slopes joining 3 and 4 are gradual; and broadly opened valleys of No. 3 finger back into the area of No. 4. At the time of its completion the masses rising above its level were, besides the main range, the rolling hills which formed as a whole a dissected terrace at its south end, and occasional knobs along the Beaver Divide to the east.

Today the remnants of No. 3 have a distinct slope away from the range, amounting to about 1° around South Pass City. The plain stands at about 8,000 feet between the Granite Hills and the main range, about 8,000 to 8,200 feet by South Pass City (the higher value at the base of the mountains), 8,200 feet between Beaver Creek and Twin Creek near O'Meara's ranch, and 7,400 feet along the upper Beaver near Atlantic City. Along the Beaver Divide it drops to 6,770 feet ten miles east of Atlantic City, and to 6,600 east of Hailey (twenty-two miles northeast of Atlantic City). The Beaver today is flowing about 400 or 500 feet below the level of this plain.

The drainage on the Beaver Divide plain is unknown. Presumably it was radially away from the range. There is no evidence that the present arrangement of streams held at that time. The slope of the plain may or may not have been what it is today. There seems no way of deciding.

This plain carries gravels on its surface only where it cuts Tertiary rocks and where these rocks contain conglomeratic layers which furnish gravel to the plain.

Plain No. 2. Table Mountain Plain.[1]—Below the Beaver Divide plain, or No. 3, a later plain (Figs. 3 and 4) was very generally developed over the Mesozoic and later rocks of the Wind River region. During this stage the Beaver Divide came into existence and the Wind River and Sweetwater drainage areas became distinct. From this time on the geological history in these two main basins is somewhat different, and the topographical forms are unlike.

The condition of Plain No. 2 in the Sweetwater area is not

[1] Since No. 2 is provisionally correlated with the plain of Table Mountain, west of Lander, it is also called the Table Mountain Plain.

clearly known. On the upper tributaries of the Sweetwater, between the Granite Hills and the main range, No. 3 is post-maturely dissected by a system of valleys which are widely opened on the gravels and are narrower on the granites. This valley system may belong to No. 2. The Sweetwater cuts the crystallines south of the Granite Hills in a narrow valley which has doubtless been cut at a later date. Further east, at South Pass City and at Atlantic City, Willow and Rock Creeks are flowing in narrow valleys, cut below broad shallow valleys which are in turn cut below No. 3. South toward Oregon Buttes, and from the Beaver Divide toward the Sweetwater, the surface drops away to lower levels in such manner as to suggest very strongly that after No. 3 had been formed a later plain was developed to a very advanced stage throughout this part of the Sweetwater basin.

The best development of No. 2, however, is north of the Beaver Divide. Along the Beaver itself large remnants of this plain occur at 6,500 feet, 300 feet below No. 3 as developed on the divide. The only area which stands above No. 2, north of the Beaver and east of the mountains, is the higher part of Sheep Mountain. The plain is well shown along the north side of Beaver Divide as a broad bench sloping to the top of the cañon of the Beaver above Hailey. It forms the flat divide between Beaver and Twin Creeks and continuing from there north makes the high country about Bruce, and either just touches or rises slightly above the hills of folded Red Beds and Cretaceous which run northwest to beyond Lander.

At the south end of the range gravel occurs on No. 2 as scattered bowlders washed from near-by regions rather than as heavy deposits swept out from the central range. For example, in climbing from the Beaver where it bends to the north, to the Beaver Divide, one finds the hill-tops which come up to No. 2 carrying scattered bowlders of angular and subangular shape, frequently five or six inches and occasionally a foot in diameter, and derived from Paleozoic and crystalline rocks. But on the summit of the divide there is found a 100-foot layer of Tertiary conglomerate with bowlders quite like those occurring on the plain below. These bowlders on No. 2 are a thin veneer of local origin, derived from

the Tertiary, and are not to be confused with the Table Mountain gravels to be considered later.

Beyond the fact that the drainage was to the Wind River and the Sweetwater, little is known of the stream courses of the time. The Beaver may have flowed out, as today, south of Sheep Mountain, or, more probably, by a longitudinal stream north toward Lander.

PLAINS-REMNANTS ON THE EAST SIDE OF THE CENTRAL WIND RIVER MOUNTAINS

The Table Mountain Level, or No. 2.—None of the plains which have been described about the south end of the Wind River Range extend continuously north along the east side of the range. There are found, however, along the front of the range, isolated gravel-covered flats, at levels which correspond with those farther south. As careful study as conditions allowed makes it practically certain that these flats correspond to either No. 2 or No. 3 described above; probably to No. 2. The vertical distance between No. 2 and No. 3 is only 300 feet, and in many places No. 2 grades up into No. 3, so that the attempt to carry either plain north and to connect it with the gravel flats is difficult; especially in the absence of topographic maps and under the necessity of carrying the lines by eye from points of view some miles off the front of the range. Provisionally, however, these gravel flats, of which the best known is Table Mountain near Lander, are correlated with Plain No. 2, which has already been called the Table Mountain plain.

The southernmost of these flats is that which occurs (Fig. 3, A) where the Lander–Atlantic City road crosses from the headwaters of Twin Creek to Red Cañon Creek, a tributary of Little Popo-Agie River. Here a terrace (7,100 feet), cut on the Red Beds, is covered by a deposit of gravel to a thickness of 50 to 100 feet as shown on the north slope toward Red Cañon. The bowlders seen over the surface are commonly less than one foot in diameter though some reach a foot, and a few are somewhat larger, but down the north face of the terrace loose bowlders up to six feet in diameter are met with. The bowlders are Paleozoic and crystalline rocks of the foothills and main range, and must have come directly from the range as no Tertiary beds are in position to act as an intermediary

in furnishing the material to the present deposit. The deposit seems to be due to aggradation by the earlier Twin Creek.

A second gravel flat tops Table Mountain south of Lander, south of the Big Popo-Agie, at an elevation of 7,200 to 7,300 feet. A slide on the north side of the Mountain shows 175 feet of gravels resting on a somewhat uneven surface of Chugwater and later beds. In the section the bowlders usually reach a size of one to three feet, but many are over five feet and one was seen ten feet in diameter. The bowlders are well rounded, closely packed, and much weathered and consist of Paleozoics and crystallines. The filling between the bowlders is a sort of granitic sand, which seems to have come from the rotting of the bowlders. From a little distance the deposit appears to be indistinctly stratified. There is no evidence that it is not stream-made, though the size of the bowlders has been thought to indicate ice-action. The bowlders, however, are not larger than those found in arid regions at the head of alluvial fans some distance out from the mouth of the feeding cañons. The slope of Table Mountain is estimated at twenty-five feet per mile away from the mountain. The slope seems too gentle for the accumulation slope of such coarse materials, and the fact that the surface of Table Mountain is not a plain, but is trenched by shallow valleys indicates that it is not original but a cut surface. The Ten Sleep sandstone ridge to the west is cut away to a level corresponding to that of Table Mountain, as if a rather broad valley had here opened out from the range.

A similar deposit of coarse gravels forms a high flat near the range on the north side of the North Fork of Little Wind River (Fig. 3, B), at an elevation of from 7,445 to 7,700 feet. These gravels have a thickness, at the south end of the exposure, of 250 feet, and lie on the inclined Chugwater beds. They consist of well-rounded bowlders up to six feet in diameter, closely packed and thoroughly rotted. Stratification here is distinct and several layers of sand and fine gravel, up to four or five feet in thickness, occur in the deposit, showing that it is water-laid. The surface relations of the deposit are shown in Fig. 7, where *A–B* is the flat under consideration. Its surface is nearly level, and it is cut by *D–E*, a more irregular plain which drops away toward the Wind

River. The slope *A–B* is not an original plain, but was cut after the deposition of the gravels, and antedates the plain *D–E*, which cuts it.

The last terrace deposit of this kind studied is on the north side of Bull Lake Creek (Fig. 3, C), at an elevation of 7,400 feet. No section is shown here, but the deposit lies above and distinct from the moraine of the earlier glacier, which occupied Bull Lake Creek Valley. It is believed to be much earlier than either of the two glaciations of the region.

The meaning of the gravels.—These high level gravels are a largely unsolved problem to us, as are similar deposits to other workers in the Rocky Mountain region. If our correlation is

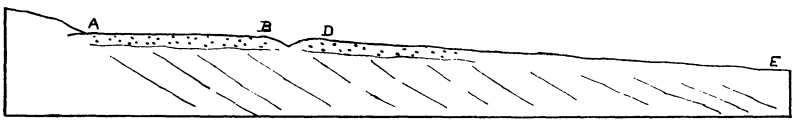

FIG. 7.—Diagram to show the relation of gravels on No. 2 (*A–B*) to the later plain (*D–E*).

correct, at some time after the up-arching of the summit peneplain which had been developed over the entire region, a peneplain was developed around the mountain on the Mesozoic and younger beds. This is plain No. 2. Low foothills of Paleozoic sandstone and limestone rose above this, and within this Paleozoic rim was the higher mass of the central crystalline area. At this time broad valleys ran back well to the crest of the range. Along Bull Lake Creek, six miles within the range, such flats were seen at 9,800 feet, and they can be seen fingering into the uplands and rising to them with not very steep slopes. This condition was followed by a period of piedmont aggradation, which resulted in the deposit of the gravels widely about the cañon mouths. This aggradation may have been the result of aridity, or of crustal movement. It was followed by the planation which produced the nearly level flats on Table Mountain, Little Wind River, and Bull Lake Creek, which have been described. Subsequent to this period of planation came the long period of terracing which produced No. 1 and lower plains.

Plain No. 1.—After the completion of No. 2, the streams again deepened their valleys and developed widely over the region a series of plains at a lower level. Along the Beaver north from Hailey a flat was formed 8 to 10 miles in width, sloping with the stream and toward the stream from either side. Near the Beaver the remnants now stand 200 feet above the stream. Above the lower Beaver cañon, a little up stream from Hailey, this plain is not shown; nor is it recognized along the Sweetwater.

The valley divide which crosses north of Twin Creek from the main range foothills to Sheep Mountain, is a remnant of No. 2, but from here north the divides between the streams which cross the valley belong to No. 1. On the Little Popo Agie–Willow Creek divide the elevation is 5,575 feet, north of Willow Creek 5,450 feet, and south of Lander 5,480 feet. The remnants of this plain slope from either side toward the axis of the longitudinal valley, indicating that the stream which controlled its formation was a longitudinal stream flowing northwest toward Lander, and that the valley was not drained as it is today, by transverse streams.

North from Lander, between the Popo-Agie and its north fork, a terrace runs far out into the valley and at Milford stands at 5,800 feet. North from this point a series of terraces occurs, below the Table Mountain levels, the highest of which are referred to level No. 1. These terraces stand at 5,730 feet between North Fork and Mill Creek, and at 5,940 feet near the road, north of the North Fork of Little Wind River. The levels rise toward the northwest, along the Wind River, and also toward the mountains.

The cutting of No. 1 was the inauguration of a period of terrace cutting which has continued to the present. New plains have been made by the swinging and deepening streams at successive lower levels, but since this terrace period has been different in the different stream basins, and since in any one basin the terraces run into each other, it was found impossible, in the absence of topographic maps, to study it in any detail. Between the North Fork of the Big Popo-Agie and the Little Wind River these lower terraces often carry large bowlders, up to 3 feet and over in diameter, which seem to have been derived from the erosion of the coarse gravels on plain No. 2, since largely destroyed.

Along the Beaver north from Hailey, No. 1 has been well dissected. During this later terracing Little Popo and Willow Creek have cut back and captured the streams which during the cutting of No. 1 had flowed northwest to Lander. In some cases there has been a recent silting-up of valleys, into which filling the present streams are again cutting. This is the case along the lower Beaver, the Wind River, and Sage Creek. The Little Wind River and the Big Popo are flowing on broad flats, and if silting has been going on they have not commenced to cut again.

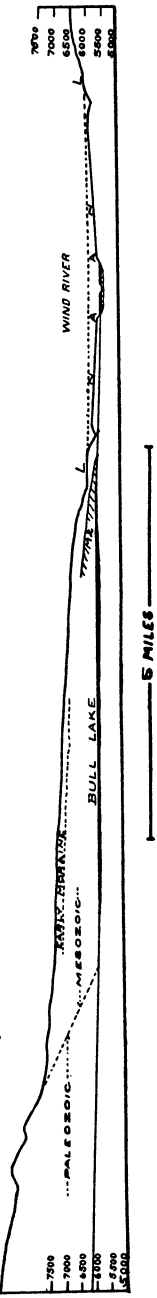

FIG. 8.—Profile along Bull Lake Creek, showing position of the two moraines and of the valley terraces. M_2, later moraine

GLACIAL HISTORY

The Wind River Mountains support a dozen or more small glaciers, and the summit region shows quite generally an Alpine topography, as a result of cirque growth (Fig. 1). In Pleistocene time glaciers occupied the main valleys, and in some cases extended a number of miles out onto the plains at the base of the range. Glacial features are considered in this paper only for the purpose of dating the terracing which has already been described, and for this purpose the conditions about Bull Lake Creek can best be used (Fig. 8).

Moraines of an earlier and a later period occur; and in each case the ice advanced about ten miles from the foot of the range, almost to the Wind River. The moraines of the later glaciation make concentric ridges about the lower end of Bull Lake, and connect with gravel outwash which floors the inner valley (Fig. 8, *A*–*A*) of Wind River. Since their deposition they have been cut somewhat where Bull Lake Creek passes through them, and along Wind River ten feet of silt has been deposited above the outwash gravels (the river is now cutting into silt and gravels); but in all

except small details the region has remained otherwise unchanged; so that at the time of the last glacial advance it was essentially as it is today.

The later moraines occur in close association with the present valley of Bull Lake Creek, either as terminal moraines below Bull Lake, or as small recessional moraines up valley. The earlier moraine, however, shows (Fig. 9) a very different relation to the present valley. At the base of the mountains it is 100 to 200 feet thick, with a typical morainic topography, and its mass of bowlders lies on inclined Mesozoic rocks several hundred feet above the floor of the valley. It was laid down in reference to a much shallower valley (probable restoration shown in Fig. 9), and the extension of the drift to the north suggests that near the Wind River

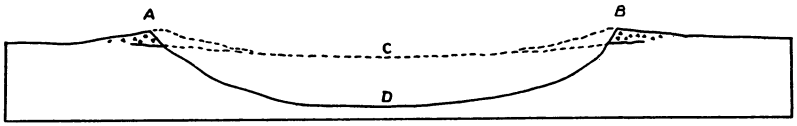

FIG. 9.—Section (diagrammatic) to show the position of the early moraine to the earlier (ABC) and present valley (ABD) of Bull Lake Creek.

the present stream departs from the course of the earlier stream. The cutting of the present Bull Lake Creek, to a depth near the mountain of some 800 feet, is the work of interglacial time.

The earlier drift is known to be older also because of its more weathered and eroded character, and because of its relations to certain terraces. The earlier moraine rests upon a terrace fragment (Fig. 8, L). Fragments of this terrace are found at a corresponding level across the Wind River. This terrace rises toward the range and is overridden by the moraine. It is therefore preearly glacial. The valley *A–A* existed before the last glacial time, since the outwash gravels of the last ice advance run into it. The cutting of the broad valley below the restored *L–L*, which is floored by the terrace *N–N*, is also the work of interglacial time, and was done at the same time that Bull Lake Creek was deepening its earlier valley. The broad terrace *L–L*, reaching back toward the range, is one of the later terraces of the Wind River region, either No. 1 or later, but it was cut before the earlier glaciation. It

follows that the long period of terracing which has been described, in which plains 4, 3, 2, and 1 were successively formed, is all to be placed before the time of the earlier glaciation. It may be that there were still earlier glaciations in the Wind River Range but if there were they have not been recognized, and for the present practically all of the higher terraces may be assigned to the Tertiary.